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Voluntary Product Standard

PS 56-73

STRUCTURAL GLUED LAMINATED TIMBER

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Standards Institute

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Voluntary Product Standard PS 56-73

Structural Glued Laminated Timber

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Abstract

This Voluntary Product Standard covers requirements for the dimensions, grade combinations, lumber for laminating, appearance grades, adhesive, and laminating of structural glued laminated timber as well as inspection and test procedures, marking, and the certification by a qualified inspection and testing agency. Definitions of the trade terms used are given, and guides for ordering and information on inspection practices are provided in the appendixes.

Key words: Glued laminated timber; laminated timber; structural glued laminated timber; timber, structural glued laminated.

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Contents

Page

1. Purpose	1
2. Scope	1
3. List of Referenced Publications	1
4. Requirements	2
4.1. General	2
4.2. Dimensions	2
4.2.1. Dimensional tolerances	2
4.3. Grade combinations	2
4.4. Lumber for laminating	2
4.4.1. Grades	2
4.4.2. Laminations	3
4.4.3. Moisture content	3
4.4.4. Wood inserts	3
4.5. Appearance grades	3
4.6. Adhesives	3
4.6.1. Dry-use adhesives	3
4.6.2. Wet-use adhesives	3
4.6.2.1. Melamine-urea combinations	3
4.6.3. Adhesive tests prior to use	3
4.6.3.1. Strength and wood failure	3
4.6.3.2. Delamination	4
4.7. Laminating	4
4.7.1. Face joint assembly and bonding	4
4.7.2. Edge joint assembly and bonding	4
4.7.3. End joint assembly and bonding	4
4.7.3.1. Knots in end joints	4
4.7.3.2. Spacing of end joints	5
5. Inspection and Test Procedures	5
5.1. General	5
5.2. In-line tests	5
5.3. Physical tests	5
5.3.1. Sampling	5
5.3.2. Tests for face joint bonding	5
5.3.3. Tests for edge joint bonding	5
5.3.4. Tests for end joint bonding	5
5.3.4.1. Strength criteria—Test 106	5
5.3.4.2. Strength criteria—Test 114	6
5.3.5. Test for integrity of glue bonds for wet-use	6
5.3.6. Tests of end joints prior to use	6
5.4. Visual inspection of finished products	6
5.4.1. Reevaluation	6
5.5. Quality control	6
5.6. Qualified inspection and testing agency	6
6. Marking	7
6.1. Marking	7
6.1.1. Withdrawal of marking	7
7. Definitions	7
8. Effective Date and Identification	8
9. History of Project	8
10. Standing Committee	8
Appendix A—Guides for ordering	8
Appendix B—Reinspection practices	9

VOLUNTARY PRODUCT STANDARDS

Voluntary Product Standards are developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The purpose of the standards is to establish nationally recognized requirements for products, and to provide all concerned interests with a basis for common understanding of the characteristics of the products. The National Bureau of Standards administers the *Voluntary Product Standards* program as a supplement to the activities of the private sector standardizing organizations.

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The role of the National Bureau of Standards in the establishment of a *Voluntary Product Standard* is to (1) act as an unbiased coordinator in the development of the standard, (2) provide editorial assistance in the preparation of the standard, (3) supply such assistance and review as is required to assure the technical soundness of the standard, (4) seek satisfactory adjustment of valid points of disagreement, (5) determine the compliance with the criteria of the Department's procedures, (6) provide secretarial functions for each committee appointed under the Department's procedures, and (7) publish the standard as a public document.

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The benefits derived from *Voluntary Product Standards* are in direct proportion to their general recognition and actual use. Producers and distributors whose products meet the requirements of a Voluntary Product Standard may refer to the standard in advertising and on labels to promote greater public understanding of or confidence in their products. Purchasers may order products conforming to the requirements of the standards.

For copies of the *Voluntary Product Standards* procedures or for more information concerning the development and use of these standards, you may write to: Office of Engineering Standards Services; National Bureau of Standards; Washington, D.C. 20234.

Structural Glued Laminated Timber

Effective July 1, 1973 (See section 9.)

(This Standard, which was initiated by the American Institute of Timber Construction, has been developed under the *Procedures for the Development of Voluntary Product Standards* of the U.S. Department of Commerce as a revision of CS 253-63, *Structural Glued Laminated Timber*. See Section 10, *History of Project*, for further information.)

1. PURPOSE

The purpose of this Voluntary Product Standard is to establish nationally recognized requirements for the production, inspection, testing, and certification of structural glued laminated timber, and to provide the producers, distributors, and users with a basis for common understanding of the characteristics of this product.

2. SCOPE

This Voluntary Product Standard covers requirements for the dimensions, grade combinations, lumber for laminating, appearance grades, adhesives, and laminating of structural glued laminated timber as well as inspection and test procedures, marking, and the certification by a qualified inspection and testing agency. Definitions of the trade terms used are given. Guides for ordering and information on inspection practices are provided in the appendices.

3. LIST OF REFERENCED PUBLICATIONS

The following publications are referenced in this Standard and may be obtained from the organizations indicated. Later issues of all publications referenced may be used provided the requirements are applicable and consistent with the issue designated; except that, later issues of AITC publications shall be used only if they have been published with the concurrence of the U.S. Forest Products Laboratory.

a. American Institute of Timber Construction
333 West Hampden Avenue, Englewood, Colorado
80110

AITC 102-72, *Standard for the Design of Structural Timber Framing*

AITC 110-71, *Standard Appearance Grades for Structural Glued Laminated Timber*

AITC 113-71, *Standard for Dimensions of Glued Laminated Structural Members*

AITC 117-71, *Standard Specifications for Structural Glued Laminated Timber of Douglas Fir, Western Larch, Southern Pine and California Redwood*

AITC 119-71, *Standard Specifications for Design of Hardwood Glued Laminated Timber*

AITC 200-73, *Inspection Manual*

USDA Technical Bulletin 1069, *Fabrication and Design of Glued Laminated Wood Structural Members*

b. American Society for Testing and Materials
1916 Race Street, Philadelphia, Pennsylvania 19103

ASTM D 2016-65, *Standard Methods of Test for Moisture Content of Wood*

ASTM D 2555-70, *Standard Methods for Establishing Clear Wood Strength Values*

ASTM D 2559-70, *Standard Specification for Adhesives for Structural Laminated Wood Products for Use Under Exterior (Wet Use) Exposure Conditions*

ASTM D 3024-72, *Performance Specifications for Protein Base Adhesives for Structural Laminated Wood Products for Use Under Interior (Dry Use) Exposure Conditions*

c. National Hardwood Lumber Association
59 East Van Buren Street, Chicago, Illinois 60605

Rules for the Measurement and Inspection of Hardwood Lumber and Cypress

d. University Forest Research Laboratory
Oregon State University, Corvallis, Oregon 97331

Forest Research Report T-26

Forest Research Report T-27

e. United States Department of Agriculture
Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

Handbook No. 72, *Wood Handbook*

f. USDA Forest Products Laboratory
P. O. Box 5130, Madison, Wisconsin 53705

Forest Products Laboratory Research Papers:

FPL 56

FPL 72

FPL 113

FPL 127

FPL 146

g. Standard Grading Rules
(approved by the Board of Review of the
American Lumber Standards Committee)

*Standard Specifications for Grades of California
Redwood Lumber*

Redwood Inspection Service
617 Montgomery Street
San Francisco, California 94111

Official Grading Rules for Eastern White Pine, Norway Pine, Jack Pine, Eastern Spruce, Balsam Fir, Eastern Hemlock, and Tamarack

Northern Hardwood and Pine
Manufacturers Assn., Inc.
Suite 207, Northern Building
Green Bay, Wisconsin 54301

Standard Grading Rules for Northeastern Lumber

Northeastern Lumber Manufacturers Assn., Inc.
13 South Street
Glens Falls, New York 12801

Standard Grading Rules for Southern Pine Lumber

Southern Pine Inspection Bureau
P. O. Box 846
Pensacola, Florida 32502

Standard Grading Rules for West Coast Lumber

West Coast Lumber Inspection Bureau
P. O. Box 23145
Portland, Oregon 97223

Grading Rules for Western Lumber

Western Wood Products Association
1500 Yeon Building
Portland, Oregon 97204

4. REQUIREMENTS

4.1. General—All structural glued laminated timber represented as conforming to this Voluntary Product Standard shall meet all of the requirements specified herein, and shall be inspected and tested in accordance with section 5 and marked in accordance with section 6.

4.2. Dimensions—The dimensions of the laminated timber shall be as agreed upon between purchaser and seller. Sizes commonly used are given in American Institute of Timber Construction (AITC) 113-71.

4.2.1. Dimensional tolerances¹—The tolerance on the dimensions shall be as follows:

Width—Plus or minus $\frac{1}{16}$ inch.
Depth—Plus $\frac{1}{8}$ inch per foot of depth.
Minus $\frac{3}{32}$ inch, or $\frac{1}{16}$ inch per foot of depth, whichever is larger.

Length—Up to 20 feet, plus or minus $\frac{1}{16}$ inch. Over 20 feet, plus or minus $\frac{1}{16}$ inch per 20 feet of length.

Squareness of cross section—Within plus or minus $\frac{1}{8}$ inch per foot of specified depth unless a specially shaped section is specified. Squareness is measured by placing one side of a square along a top or bottom face and determining the offset from the other side of the square to the side of the member (see figure 1).

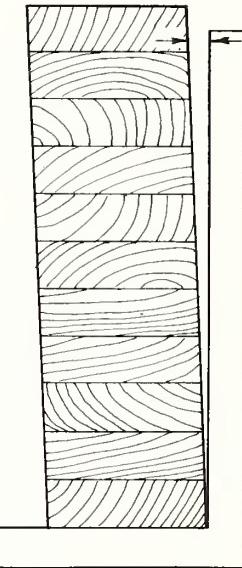


FIGURE 1. Measuring squareness.

4.3. Grade combinations—The grade combinations for structural glued laminated timber shall be as provided in the current editions of AITC 117-71 and AITC 119-71. These specifications have been developed in accordance with the U.S. Department of Agriculture (USDA) Technical Bulletin 1069 as modified by test data contained in Forest Products Laboratory (FPL) Research Papers FPL 56, FPL 72, FPL 113, FPL 127, FPL 146, and Oregon State University Forest Research Reports T-26 and T-27, and by test data approved by the FPL. Other grade combinations of these species, other species, or regional species groups may be used provided allowable unit stresses are established for them in accordance with this section.

4.4. Lumber for laminating

4.4.1. Grades—All softwood lumber used in laminated timbers shall be graded under standard grading rules or special laminating grading rules approved by the Board of Review of the American Lumber Standards Committee² (see section 3 for approved grading rules). Such grades of lumber shall

¹Industry practices for camber are contained in AITC 102-72.

be modified if necessary according to the principles set forth in USDA Technical Bulletin 1069 or by supplemental requirements as set forth in the laminating specification for the species. Only those hardwood species included in the standard grading rules of the National Hardwood Lumber Association shall be used in the laminated timbers.³ The knot size and slope of grain requirements and other supplemental requirements shall be as set forth in AITC 119-71.

4.4.2. Laminations—All laminations (see definition) used in the timber shall be identified by grade prior to gluing. Laminations used in nonstructural areas of the timbers need not be stress-graded. The laminations shall not exceed 2 inches in net thickness. Variations in thickness across the width or along the length of any lamination shall not exceed plus or minus 0.008 inch. Cup shall not exceed $\frac{1}{32}$ inch for each inch of width of laminations with a nominal thickness of 1 inch or less, and shall not exceed $\frac{1}{64}$ inch for each inch of width of laminations with a nominal thickness over 1 inch. Warp shall not be so great that it will not be straightened out by pressure in gluing. All gluing surfaces including face, edge, and end joints shall be smooth and free of raised grain, torn grain, skips, burns, glazing, or other deviations from the plane of the surface that might interfere with the contact of sound wood fibers in the mating surfaces. All gluing surfaces shall be free from dust, foreign matter, or exudation which might be detrimental to satisfactory gluing.

4.4.3. Moisture content—The moisture content of the laminations shall be less than 16 percent at the time of gluing; except that, when it is known that the equilibrium moisture content of the laminated timber in use will be 16 percent or more, the moisture content of the laminations at the time of gluing shall not exceed 20 percent. The range of moisture contents of the laminations to be assembled into a single timber shall not exceed 5 percentage points if any lamination exceeds 12 percent. The moisture content determinations shall be made in accordance with American Society for Testing and Materials (ASTM) D 2016-65.

4.4.4. Wood inserts—The moisture content of inserts shall be in accordance with 4.4.3. The same general type of adhesive required for face joint bonding shall be used for bonding inserts. Inserts shall be matched for color and grain in accordance with AITC 110-71. When an insert is placed in a lamination prior to face joint bonding, the thickness of the insert shall meet the same machining tolerances as specified in 4.4.2 for the lamination. No inserts shall be used in any tension lamination located in the outer 5 percent of total depth of a bending member in that portion of a member in which end joint spacing is required (see 4.7.3.2).

4.5. Appearance grades—The laminated timber shall be either industrial, architectural, or premium appearance grade as defined in AITC 110-71.

4.6. Adhesives—Adhesives shall be either dry-use or wet-use conforming to 4.6.1 or 4.6.2 of this Standard. Straight urea adhesives shall not be used in structural glued laminated timber. Each shipment of adhesive shall be identified with the name of the manufacturer, the name or designation of the adhesive, the adhesive manufacturer's batch number, and the date after which the adhesive should not be used.

4.6.1. Dry-use adhesives—Casein adhesives conforming to ASTM D 3024-72 may be used when the moisture content of the wood is not expected to exceed 16 percent for repeated or prolonged periods but shall not be used when these moisture conditions are exceeded.

4.6.2. Wet-use adhesives—Wet-use adhesives conforming to ASTM D 2559-70 may be used for all moisture conditions but must be used when the moisture content of the wood is expected to exceed 16 percent for repeated or prolonged periods of service.

4.6.2.1. Melamine-urea combinations—Melamine-urea combinations in which the melamine is at least 60 percent by weight solid resin content and which meet the requirements of ASTM D 2559-70, may be used; except that, they shall not be used for hardwoods or woods chemically treated before or after gluing. However, they may be used to end join untreated wood to wood treated with pentachlorophenol in a volatile solvent such as liquid petroleum gas, provided the end joint is located in a dry-use exposure condition.

4.6.3. Adhesive tests prior to use—Each batch of adhesive used for laminating structural timber shall be tested by the laminator in accordance with 4.6.3.1 and 4.6.3.2 prior to use. The tests shall be made on specimens which have been manufactured from the species to be used in the structural timber.

4.6.3.1. Strength and wood failure—Block shear tests shall be performed in accordance with AITC 200-73, Test 101, for wet-use and dry-use adhesives. The average shear strength shall be at least equal to the values specified in table 1. For wet-use adhesives used with all species and for dry-use adhesives used with softwoods and nondense hardwoods, the sheared or broken surfaces shall be at least 80 percent average wood failure. For dry-use adhesives used with dense hardwoods, the average wood failure shall be not less than 40 percent. When adhesives that are used only for end joint bonding cannot be face joint bonded with existing plant equipment, these adhesives may be tested using AITC 200-73, Test 106 or 114. A minimum of four end joints shall be tested. Average wood failure shall

²Address: Post Office Box 1554, Rockville, Maryland 20850
³Address: 59 East Van Buren Street, Chicago, Illinois 60605

be as required for the block shear test. Average strength required shall be as given in 5.3.4.1 for Test 106 or 5.3.4.2 for Test 114.

4.6.3.2. Delamination—Delamination tests shall be performed in accordance with AITC 200-73, Test 108, 109, or 110 for wet-use adhesives. Softwoods shall have not more than 5 percent delamination and hardwoods shall have not more than 8 percent delamination.

TABLE 1. *Required shear strength of adhesive joints in laminated construction of different species at various moisture content values*

Species ^a	Moisture content			Increase in shear strength for each 1% decrease in moisture content ^c percent
	8%	12%	16%	
	psi	psi	psi	
California redwood	1,000	900	820	2.5
Douglas fir	1,210	1,100	1,000	2.4
Hem-Fir ^b	1,170	1,040	930	2.9
Larch, Western	1,360	1,220	1,090	2.8
Maple, sugar	2,420	2,100	1,820	3.6
Oak, red	1,790	1,600	1,420	2.9
Oak, white	2,080	1,800	1,560	3.7
Pine, lodgepole	850	790	730	1.9
Pine, Southern	1,530	1,250	1,020	5.2

^a For other species, values shall be based on 90 percent of the shear strength parallel to grain as determined from the data and procedures presented in ASTM D 2555-70. Adjustments for changes in moisture content shall be on the basis of applying the "exponential formula" as described in the U.S. Department of Agriculture Handbook No. 72 to the basic stress data contained in ASTM D 2555-70.

^bThis includes western hemlock and grand, noble, white, California red, and Pacific silver fir.

^cIn order to determine the increase in shear strength for each 1 percent decrease in moisture content, multiply the strength by $(1 + P)$, where P is the percentage shown in the table. This should be computed successively until the total change has been covered.

4.7. Laminating—The selection and preparation of lumber and adhesive shall be in accordance with 4.4, 4.5, and 4.6. The mixing of the adhesive, the interval between mixing and spreading, the spreading, the assembly time, the assembly pressure, and the curing time of the adhesive shall be in accordance with the adhesive manufacturer's recommendation. Ingredients for each adhesive mix shall be determined by weight. The mixed adhesive shall be applied uniformly to the wood surfaces in an amount adequate to meet the performance requirements of this Standard. Determination of the adhesive spread rate shall be made in accordance with AITC 200-73, Test 102. No adhesive shall be used after expiration of its storage or pot life. Lumber temperature shall not be less than 36°F at the time of gluing, but higher lumber temperatures may be required in many cases. Adjustments in assembly time, quantity of adhesive spread, and curing conditions shall be made depending on lumber temperature. The adequacy of adjustments shall be demonstrated by tests at the lowest and highest temperatures at which laminating takes place. Assembly pressures shall be a minimum of 100 psi and a maximum of 250 psi, with the lower range for softwoods and the higher pressures for dense hardwoods. In no

case shall pressure exceed the compression perpendicular-to-grain allowable working stresses for the species being glued as specified in applicable laminating specifications. Curing of adhesives shall be in accordance with AITC 200-73.

4.7.1. Face joint assembly and bonding

Face joints shall have pressure applied at uniformly spaced points starting at any point, but progressing toward an end or ends. The pressure shall be progressively and uniformly applied, and shall be maintained for a sufficient period of time so as to insure close contact between the laminations and not overstress glue lines during development of the bond strength. Checking of the pressure shall be required and further application of pressure, within 20 to 60 minutes, may be necessary before substantial cure has begun, dependent upon conditions after initial application of full pressure. Nailing of the structural portion of laminations in lieu of clamping pressure shall not be permitted.

4.7.2. Edge joint assembly and bonding

Edge joints need not be glued except when occurring in members which are designed for loading parallel to the wide face of the lamination, or in members where the edge joint is loaded in shear. When edge joints are not preglued, they shall be staggered laterally in adjacent laminations by at least the net thickness of the lamination. When edge joints are preglued in accordance with the requirements of 4.7, they need not be staggered laterally.

4.7.3. End joint assembly and bonding

End joints may be preglued or they may be assembled and bonded integrally with the face joint operation. The thickness tolerance in end joint areas at the time of face joint bonding shall be within plus 0.020 inch to minus 0.005 inch of the thickness of the lumber being joined. The thickness of exposed tips of plane scarf joints or finger joints which occur across the full width of the face of the laminations shall not exceed $\frac{1}{32}$ inch. When end joints are glued integrally with the face joint bonding of laminations, they must be positively maintained in alinement while the face joint bond is accomplished. Positioning and alinement methods shall permit checking of tolerances with gages. End joints for the production of curved members shall be preglued unless the assembled thickness tolerance of the end joint area and alinement can be maintained by other methods. End joints shall be glued in accordance with the requirements for face joint bonding with appropriate modifications to the adhesive spreading, assembly times, pressures, and curing times for methods used.

4.7.3.1. Knots in end joints

Knots or knot-holes in plane scarf joints shall be limited to those permitted for the lumber grade, but in no case shall they exceed one-fourth the nominal width of the piece in the laminations that occupy the outer 10 percent on each side of bending members and in any lamination of tension members. Knots shall not occur

within finger joints. In bending members, knots shall not occur within two knot diameters or 6 inches, whichever is less, of finger joints in the outer 20 percent of the laminations on the tension side, nor within one knot diameter of finger joints in the balance of the laminations. In tension members, knots shall not occur within two knot diameters or 6 inches, whichever is less, of finger joints in any lamination. Measurement of the knot diameter shall be parallel to the longitudinal axis of the piece of lumber. The distance of knots from finger joints shall be measured from the edge of the knot nearest the joint to the closest point of the joint.

4.7.3.2. Spacing of end joints—A random spacing of end joints is desired in production, avoiding concentrations of end joints whenever possible. The spacing for finger joints is determined by measuring the distance between any portion of the joints in adjacent laminations in a direction parallel to the longitudinal axis of the laminations. The spacing of scarf joints is determined by measuring the distance between tips along the face joint bond of adjacent laminations. End joints shall be dispersed, as a minimum, as given in (a), (b), and (c) below:

(a) Tension members—End joints in tension members loaded to 75 percent or more of allowable design stress shall be spaced 6 inches apart in adjacent laminations. Furthermore, a plane at right angles to the axis of the member that intersects a scarf joint in a lamination shall not intersect any part of another scarf joint in adjacent laminations.

For members loaded to less than 75 percent of allowable design stress, one single occurrence of two joints in adjacent laminations spaced closer than 6 inches is permitted for any 30 feet of length.

(b) Tension portion of bending members—The minimum spacing of end joints in adjacent laminations in the tension portion of bending members for the outer one-eighth of the depth of the member plus one lamination shall be 6 inches. This spacing applies over the central 75 percent of the zone stressed in tension. Furthermore, a plane at right angles to the axis of the member that intersects a scarf joint in a lamination shall not intersect any part of another scarf joint in adjacent laminations. There are no minimum spacing requirements for the remaining portion of the tension zone.

When, for specific loadings of a member, engineering calculations are used to determine zones in the tension portions which are loaded to 50 percent or more of maximum allowable design stress, the minimum spacing requirements apply only to these zones.

(c) Compression members and compression portion of bending members—There are no require-

ments for minimum spacing of end joints in compression members or in the compression portion of bending members.

5. INSPECTION AND TEST PROCEDURES

5.1. General—The inspection and test procedures to be used in the production of structural glued laminated timber consist of in-line tests, physical tests, visual inspection, and certification by a qualified inspection and testing agency (see 5.6).

5.2. In-line tests—In-line tests conducted at production checkpoints shall include the checking of moisture content, surfacing, temperature, end joints, edge joints, face joints, adhesive mixing, adhesive spread, assembly time, pressure, and curing conditions. All checking shall be conducted in accordance with AITC 200-73.

5.3. Physical tests

5.3.1. Sampling—One sample shall be taken from every 50,000 feet board measure, or portion thereof, which is glued during each work shift. Face, edge, and end joint bonding and each combination of wood species, types of adhesive, and treatment used during the work shift shall be represented in the sampling. The samples shall be cut either from the ends of production timber or from special samples representative of production timber made under the production conditions. The selection of test specimens from the samples shall be in accordance with AITC 200-73.

5.3.2. Tests for face joint bonding—Block shear tests on glue lines between laminations shall be conducted in accordance with AITC 200-73, Test 107. The average shear strength values of the test samples shall be at least equal to the values specified in table 1. The sheared or broken surfaces of the test samples shall develop at least 70 percent average wood failure for wet-use adhesives used with all species and for dry-use adhesives used with softwoods and nondense hardwoods. The average wood failure shall be not less than 35 percent for dry-use adhesives used with dense hardwoods.

5.3.3. Tests for edge joint bonding—Where edge joint bonding is a structural requirement, block shear tests shall be conducted as for face joint bonding with appropriate modification of width depending upon the thickness of the lamination. The criteria specified in 5.3.2 shall be met.

5.3.4. Tests for end joint bonding—End joints shall be tested for wood failure and strength in accordance with AITC 200-73, Test 106 or 114. The criteria for wood failure shall be as specified in 5.3.2 for face joint bonding.

5.3.4.1. Strength criteria—Test 106—The criteria for strength for Test 106 shall be as follows:

Criterion (1) The average ultimate load value

shall be at least 2.73 times the highest allowable bending stress level for normal conditions of loading being used in design. Example: If 2400 psi is the highest allowable stress value for normal conditions of loading, the average ultimate value for the specimens tested must be at least $2400 \times 2.73 = 6550$ psi (rounded off to nearest 10 psi).

Criterion (2) All test values must exceed 2.0 times the highest allowable bending stress values for normal conditions of loading being used in design.

5.3.4.2. Strength criteria—Test 114—The criteria for strength for Test 114 shall be as follows:

Criterion (1) The average ultimate load value shall be at least 3.15 times the highest allowable bending, tension, or compression stress value for normal conditions of loading to be used in design.

Criterion (2) All test values must exceed 2.0 times the highest allowable bending, tension, or compression stress value for normal conditions of loading used in design.

5.3.5. Test for integrity of glue bonds for wet-use—Cyclic delamination tests made in accordance with AITC 200-73, Test 108, 109, or 110 shall be conducted on samples from face joints and end joints, and on edge joints when the edge joint bonding is a structural requirement. The glue lines shall be evaluated in accordance with AITC 200-73, Test 108. Delamination shall not exceed 10 percent.

5.3.6. Tests of end joints prior to use—All configurations of end joints shall be tested prior to the first production use on each species (or group of species which have closely similar strength and gluing characteristics)—adhesive—treatment combination laminated by the plant. Straight bevel scarf end joints with a slope of 1 in 8 or flatter shall be tested in conformance with Test 112. Other types of end joints and straight bevel scarf end joints with a slope steeper than 1 in 8 shall be tested in accordance with Test 113. The criteria for strength are as follows:

Criterion (1) The average ultimate load value shall be at least 3.15 times the highest allowable bending, tension, or compression stress value for normal conditions of loading being used in design.

Criterion (2) Ninety-five percent of the test values must exceed 2.36 times the highest allowable bending, tension, or compression stress value for normal conditions of loading being used in design.

Criterion (3) All test values must exceed 2.0 times the highest allowable bending, tension, or compression stress value for normal conditions of loading used in design.

5.4 Visual inspection of finished products—All production shall be inspected visually for conformance to the requirements of this Standard and the job specifications as to:

- (a) Dimensions (width, depth, and length);

- (b) Shape, including camber and cross section;
- (c) Type, quality, and location of edge and end joints;
- (d) Appearance grade;
- (e) Lumber species and orientation of grades;
- (f) Apparent moisture content;
- (g) Adhesive type (dry-use or wet-use) (If the adhesive appears to have the wrong color, the type must be ascertained from records or determined by suitable test); and
- (h) Glue lines. If glue line thicknesses do not fall within the range of 0.006 inch plus or minus 0.004 inch, investigation of the production procedures shall be made to assure conformance with this Standard. Infrequent occurrences of separations of glue line shall be so limited in amount that they shall not, in the judgment of a qualified inspector, affect the structural integrity of the member in an amount greater than the characteristics permitted in the lamination grade. Any separation of glue line shall require investigation of the records and production procedures, and may require additional physical tests. Probes, increment borings, or other means may be used to evaluate the structural effect of the separations.

5.4.1. Reevaluation—If visual inspection discloses that the finished product does not conform in all respects to the requirements of the applicable job specification, and where structural integrity is not affected thereby, it may be possible in certain cases to provide conformance through modifications in the dimensions, shape, and appearance grade of the product, or in the job specification, provided there is buyer approval.

5.5 Quality control—The quality control system of the laminator shall be in accordance with AITC 200-73.

5.6. Qualified inspection and testing agency—A qualified inspection and testing agency is defined as one that:

- (a) operates an inspection system which examines for adequacy the quality control system of its contracting plants;
- (b) provides the facilities and the personnel to perform the inspection and to verify the testing as described herein;
- (c) determines the individual plant's ability to produce in accordance with this Standard;
- (d) provides periodic inspection of the plant's production operations and production quality to assure compliance with this Standard;
- (e) enforces the proper use of the inspection agency quality marks and certificates;
- (f) has no financial interest in, or is not financially dependent upon, any single company manufacturing any portion of the product being inspected or tested and
- (g) is not owned, operated, or controlled by any such company; and
- (h) provides a technical review board to advise

the inspection and testing agency and to arbitrate disputes between the agency and the laminator. Such a review board shall consist of:

- (1) a recognized independent authority in the field of engineered timber construction to serve as chairman and,
- (2) at least one of the members shall be a registered engineer knowledgeable in the design and use of structural glued laminated timber.

6. MARKING

6.1. Marking—Structural glued laminated timber represented to comply with this Standard shall be distinctively marked with the following:

- (a) the identification of this Voluntary Product Standard, PS 56-73;
- (b) the identification of a qualified inspection and testing agency (see 5.6);
- (c) the identification of the laminating plant;
- (d) the species of lumber in the timber;
- (e) the applicable laminating specification and combination symbol;
- (f) identification of structural use⁴ denoted by the symbols B—simple span bending member; C—compression member; T—tension member; CB—simple, continuous or cantilever span bending member;
- (g) the letter "D" or "W," as applicable, denoting dry-use or wet-use adhesives; and
- (h) the appearance grade, e.g., Industrial (Ind.), Architectural (Arch.), or Premium (Prem.).

For members laminated to meet specific job specifications, the marking need only consist of items a, b, and c.

6.1.1. Withdrawal of marking—If physical tests indicate that a marked or certified product is not in conformance with the requirements of this Standard and if further investigation shows that the material is structurally inadequate for the use intended, such marking or certification of the product shall be withdrawn.

7. DEFINITIONS

For the purposes of this Standard the following definitions shall apply:

Assembly time—The time interval between the spreading of the adhesive on the laminations and the application of final pressure or heat, or both, to the entire assembly.

Batch—Generally used by adhesive manufacturers to identify a "lot" or a "blending" or "cook" of adhesive.

Bending members—Members that are stressed principally in bending such as beams, girders, and purlins.

Camber—The small amount of curvature which can be built into a glued laminated timber to offset anticipated deflection movement. It may also be used to facilitate roof drainage.

Compression members—Members that are stressed prin-

cipally in axial compression such as posts, columns, compression chords of trusses, and arches.

Curing time—The period of time which an adhesive takes to attain its full strength.

Curved members—Members which are designed so that significant curvature remains after deflection due to service loads has taken place, such as curved beams and arches.

Delamination—The separation of layers in an assembly because of failure of the adhesive, either in the adhesive itself or at the interface between the adhesive and the lamination.

Depth—The dimension of the cross section which is measured parallel to the direction of the principal load on the member in bending.

Equilibrium moisture content—Any piece of wood will give off or take on moisture from the surrounding atmosphere until the moisture in the wood comes to equilibrium with that in the atmosphere. The moisture content of the wood at the point of balance is called the equilibrium moisture content and is expressed as a percentage of the oven-dry weight of the wood.

Face joint—The joint occurring between the wide faces of laminations.

Glue line—The area occupied by the glue between pieces of wood which are joined by adhesives which is called a "line," since only the edge is visible in a finished member.

Hardwood, nondense—Any hardwood having an average specific gravity of 0.42 or less when determined by oven-dry weight and green volume.

In-line tests—Testing conducted during manufacture rather than on the finished product.

Inserts—Nonstructural repairs to correct appearance defects.

Joint area—Describes the area of the glue line and is usually expressed in square feet.

Joint, edge—A side joint in laminations formed by the use of two or more widths of lumber to make up a full width lamination.

Joint, end—A joint formed by joining pieces of lumber end to end with adhesives.

Joint, finger—An end joint made up of several meshing tongues or fingers of wood.

Joint, scarf—An end joint formed by joining with adhesive the ends of two pieces that have been tapered to form sloping plane surfaces. In some cases, a step or hook may be machined into the scarf to facilitate alignment of the two ends, in which case, the plane is discontinuous and the joint is known as a stepped or hooked scarf joint.

Laminating—The process of bonding laminations together with adhesive including the preparation of the laminations, preparation and spreading of adhesives, assembly of laminations in packages, and pressure and curing.

Lamination—A full width and full length layer contained in a member bonded together with adhesives. It may be composed of one or several wood pieces in width or length but only one in depth. Wood pieces may be end or edge glued.

Moisture content—The amount of water contained in the wood, usually expressed as a percentage of the weight of the oven-dry wood.

Nonstructural—The portion of a member which was not used by the designer in calculating the allowable loads of the member.

⁴Members intended to be used as tension members should be laminated to meet specific job specifications.

Pot life—The period of time during which an adhesive, after mixing with catalyst, solvent, or other compounding ingredients, remains suitable for use.

Principal members—The major load-carrying members of a structure, such as beams, girders, columns, arches, chord members of trusses and framed arches, and rigid frames.

Production check-points—Those locations in production where an individual production step has been completed and is checked for conformance to the requirements of this Standard.

Relative humidity—Ratio of actual pressure of existing water vapor to maximum possible pressure of water vapor in the atmosphere at the same temperature, expressed as a percentage.

Representative sample—Portions or sections of glued laminated timber that represent all of the conditions surrounding the manufacturing process.

Storage life—The period of time during which a packaged adhesive can be stored under specified temperature and humidity conditions and remain suitable for use.

Structural glued laminated timber—An engineered, stress-rated product of a timber laminating plant comprising assemblies of specially selected and prepared wood laminations securely bonded together with adhesives. The grain of all laminations is approximately parallel longitudinally. They may be comprised of pieces end joined to form any length, of pieces placed or glued edge-to-edge to make wider ones, or of pieces bent to curved form during gluing.

Tension members—Members that are stressed principally in axial tension such as the tension chords in trusses and tension tie members.

Test specimen—All or part of a sample that has been selected for testing.

Width—The dimension of the cross section which is measured perpendicular to the direction of the principal load on the member in bending.

Wood failure—The rupturing of wood fibers expressed as the percentage of the total area involved which shows such failure.

8. EFFECTIVE DATE AND IDENTIFICATION

The effective date of this Standard is July 1, 1973. After this date, the authority to refer to the superseded standard, Commercial Standard CS 253-63, *Structural Glued Laminated Timber*, as a voluntary standard developed under the Department of Commerce procedures is terminated. As of the effective date, reference to PS 56-73 may be made in contracts, codes, advertising, invoices, product labels, and the like, but no product may be advertised or represented in any manner which would imply or tend to imply approval or endorsement of that product by the National Bureau of Standards, the Department of Commerce, or by the Federal Government.

The following statements are suggested for use in representing products as conforming to all requirements of this Standard:

- (1) "This laminated timber conforms to all requirements established in Voluntary Product Standard PS 56-73, *Structural Glued Laminated Timber*, developed and published in accordance with the U.S. Department of Commerce *Procedures for the Development of Voluntary Product Standards*. Full responsibility for the conformance of this product

to the standard is assumed by (name and address of producer or distributor)."

- (2) "Conforms to PS 56-73, (name and address of producer or distributor.)"

9. HISTORY OF PROJECT

Commercial Standard CS 253-63, *Structural Glued Laminated Timber*, was developed at the request of the American Institute of Timber Construction and was published in 1963.

In 1970, the American Institute of Timber Construction requested that the National Bureau of Standards initiate a revision of CS 253-63 under the *Procedures for the Development of Voluntary Product Standards*. A proposed revision was approved by the Standing Committee in June 1972. The recommended revision was then circulated for acceptance in July 1972. The response to this circulation indicated that certain changes to the standard were necessary. A new proposal was approved by the Standing Committee in October 1972. The new recommended standard was circulated for acceptance in January 1973. The responses to this circulation indicated a consensus among producers, distributors, and users, in accordance with the published procedures.

The new edition of the Standard was designated Voluntary Product Standard PS 56-73, *Structural Glued Laminated Timber*, and became effective on July 1, 1973.

Technical Standards Coordinator:

Karl G. Newell, Jr., Office of Engineering Standards Services,
National Bureau of Standards, Washington, D.C. 20234

10. STANDING COMMITTEE

A Standing Committee has been appointed to assist in keeping this *Voluntary Product Standard* up to date. The names of the members of the committee are available from the Office of Engineering Standards Services, Washington, D.C. 20234, which serves as the secretariat of the committee.

APPENDIX A. Guides for ordering

The following is a recommended guide for ordering structural glued laminated timber.

A1. General—All structural glued laminated timber shall be as shown detailed on the plans and specified herein, and shall conform to Voluntary Product Standard PS 56-73, *Structural Glued Laminated Timber*.

A2. Lumber—Lumber for laminating shall be of such stress grade to provide glued laminated timbers with allowable working stress values for loads of normal duration of _____ psi in bending, _____ psi in tension, and _____ psi in compression parallel to grain for (check one):

- Dry condition of use
 Wet condition of use

A3. Adhesives—Adhesives shall meet the requirements for (check one):

- Dry-use (Water-resistant)
 Wet-use (Waterproof)

A4. Appearance grades—Appearance of members shall be (check one):

- () Industrial appearance grade
- () Architectural appearance grade
- () Premium appearance grade

A5. Protection—Surfaces of members shall be (check one):

- () Sealed with penetrating sealer
- () Sealed with sealer coat
- () Other type of finish (specify) _____

- () Not sealed

—Members shall be (check on):

- () Individually wrapped
- () Bundle wrapped
- () Not wrapped

A6. Preservation

- () Preservative treatment not required
- () Preservative treatment required
 - The preservative shall be _____
 - The retention shall be _____
 - The penetration shall be _____

A7. Dimensions—All dimensions shall conform to the details as shown on the approved shop drawings.

A8. Quality marks and certificates (check one):

—Members shall be marked with a qualified inspection and testing agency mark indicating conformance with the Voluntary Product Standard PS 56-73, *Structural Glued Laminated Timber*, or

—Members shall be marked with a qualified inspection and testing agency mark and, in addition, a certificate from a qualified inspection and testing agency shall be provided to indicate conformance with the Voluntary Product Standard PS 56-73, *Structural Glued Laminated Timber*.

APPENDIX B. Reinspection practices

B1. General—Compliance with gluing provisions of job specifications can be checked and verified during the manufacture of structural glued laminated timber provided such compliance is based on performance testing and on an inspection of con-

ditions and procedures during all stages of the manufacturing process. A different condition exists in attempting to determine compliance with requirements for glue line quality in finished production, and such determination other than by visual inspection is not always practicable and feasible. For example, indisputable proof of the structural integrity of glue line quality in a finished member may be satisfactorily established in some cases only at the risk of rendering the member unfit or worthless for the purpose for which it was produced. Table B1 is a summary of the physical tests. In order to protect the seller against unfairness in situations of this kind and also to provide fair and equitable treatment to the purchaser, the provisions of this appendix are offered in the interest of fair trade practice.

B2. Complaint adjustment responsibility

—The shipment of structural glued laminated timber should comply with job specifications in all respects but any complaint requiring an adjustment in the invoice or material should be filed with the seller in writing within 15 days after receipt of unwrapped products, or 15 days after unwrapping wrapped products. If a purchaser requests adjustment from the seller on any material claimed by him to be unsatisfactory, he should hold such material intact in the same form as shipped for such reasonable time as may be necessary to permit inspection by the qualified inspection and testing agency and should protect it from damage or from conditions that would cause serious degrade or deterioration in quality.

B3. Purchaser and seller responsibility after reinspection—To the extent that material

deficient in quality is determined through reinspection to be a responsibility of the seller, the purchaser should be relieved of responsibility for accepting such material, but the purchaser should be obligated to accept such material as complies with the job specifications or for which he is responsible.

B4. Reinspection costs—If it is determined through reinspection that the material under complaint meets the specified requirements, the purchaser should be obligated to accept such material and pay the cost of reinspection, but if it does not meet specified requirements, the seller should be obligated for this cost.

TABLE B1. *Summary of physical tests for daily production*

Test performed on	Minimum number of samples per sampling period	Minimum number of specimens per sampling period	AITC test number and type of test	Requirements or limitations for	Reference (paragraphs within this Standard)
All face joints and edge joints ^c	1 ^a	10 ^b	107-block shear	Strength and wood failure	5.3.2. and 5.3.3.
Face and edge joints ^c with wet-use adhesives	1 ^a	1	108 or 109 or 110-cyclic delamination	Glue line openings	5.3.5
All end joints	1 ^a	5	106-tension or 114-bending	Strength and wood failure ^d	5.3.4
End joints with wet-use adhesives	1 ^a	1	108 or 109 or 110-cyclic delamination	Glue line openings	5.3.5

^aFor each adhesive-species-treatment combination used. The sampling period is described in 5.3.1. Species of similar strength and gluing characteristics, when glued concurrently, can be grouped together and the test of one species can apply to all species in this group for a given sampling period. The sampling of species from day-to-day should be approximately in proportion to the volume of production of each species in the plant.

^bFor 10 or more glue lines. If production member contains less than 10 glue lines, a minimum of 10 specimens shall be prepared, but each glue line shall be tested.

^cWhen edge joint gluing is a structural requirement.

^dWood failure and strength may be determined from the same set of specimens.

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Office of Standard Reference Data — Office of Technical Information and Publications — Library — Office of International Relations.

¹ Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.

² Part of the Center for Radiation Research.

³ Located at Boulder, Colorado 80302.

⁴ Part of the Center for Building Technology.

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